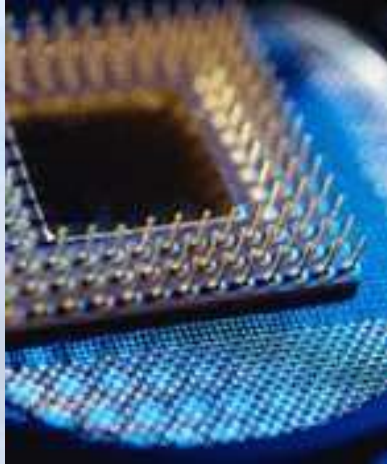


# **AB 32 Discrete Early Action Measure**

## **Semiconductor and Related Devices Second Public Workshop**



**California Air Resources Board  
Sacramento, CA  
April 23, 2008**

# Webcast Viewers

Please send your emails via:

[www.sierrarm@calepa.ca.gov](mailto:www.sierrarm@calepa.ca.gov)

# Outline

- Overview
- Applicability
- Draft Definitions
- Preliminary Survey/Emissions Estimates Results
- Future Activities

# Overview

# California Global Warming Solutions Act of 2006 (AB 32)

- The California Global Warming Solutions Act of 2006 requires the ARB to identify a list of discrete early action greenhouse gas emission reduction measures.
- On October 25, 2007, the Board approved the Semiconductor and Related Devices Emissions Reduction Strategy as a discrete early action measure.
- This measure is scheduled to be adopted by the Board, and become enforceable by January 1, 2010.

# Applicability

# Semiconductor and Related Devices Measure

- Applies to any establishment that uses fluorinated gases or liquids in the research, manufacturing or testing of semiconductor and related solid state devices. This includes, but is not limited to, semiconductor diodes and stacks, rectifiers, integrated microcircuits for semiconductor networks, transistors, solar cells, and light sensing and emitting semiconductor (solid-state) devices.

# Definitions



- **Abatement:** Commercially available technologies that reduce or eliminate fluorinated gases used in either, or both, the etching and chemical vapor deposition (CVD) chamber cleaning processes. Abatement includes, but is not limited to, natural gas fuel burners, catalytic reactors, electrically heated chambers, plasma reactors and water scrubbers.

- **Alternative Chemistries:** The substitution of another source gas for a fluorinated source gas in the chamber cleaning or etching process to increase utilization efficiency and reduce the global warming potential of the process emissions.

- **Chamber Cleaning:** The process of using fluorinated gases to remove excess materials from chemical vapor deposition chamber walls to prevent contamination of wafers being processed.

- **Chemical Vapor Deposition (CVD):**  
Deposition of thin films (usually dielectrics/insulators) on silicon wafers by placing the wafers in a mixture of gases, including nitrogen or another carrier gas, which react at the surface of the wafers.

- **Etching:** A chemical reactive process for selectively removing material on a silicon wafer during manufacturing. Etching includes wet etching with chemicals, such as buffered hydrofluoric acid, or dry etching with fluorinated, ionized gases.

- **Fluorinated Gases:** Any compound that contains fluorine and exists in a gaseous state at 25 degrees Celsius and 1 atmosphere of pressure. Fluorinated gases include, but are not limited to:

hexafluoroethane ( $C_2F_6$ ),  
octofluoropropane ( $C_3F_8$ ),  
tetrafluoromethane ( $CF_4$ ),  
trifluoromethane ( $CHF_3$ ),  
octofluorocyclobutane ( $c-C_4F_8$ ),  
octofluorotetrahydrofuran ( $C_4F_8O$ ),  
hexafluoro-1,3-butadiene ( $C_4F_6$ ),  
nitrogen trifluoride ( $NF_3$ ), and  
sulfur hexafluoride ( $SF_6$ ).

- **Global Warming Potential (GWP):** The ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of carbon dioxide (CO<sub>2</sub>) over a specified time period.

- **Heat Transfer Fluid (HTF):** A fluid which prevents a device, such as a semiconductor, from overheating by removing excess heat produced during a manufacturing process.



- **Plasma:** An ionized fluorinated gas created by exposing the gas at low pressure to an electric or electromagnetic field.

- **Plasma Etching:** A form of plasma processing in which ions (charged species) in a plasma, formed above a masked substrate are directed to impact the non-masked regions of the substrate to remove atoms.

- **Process Optimization:** The practice of using end-point detectors and/or process parameter variation to achieve optimum gas usage to reduce excess fluorinated gas emissions.

- **Remote Plasma:** The process of using an external device to heat gases such as  $\text{NF}_3$  or  $\text{C}_3\text{F}_8$  to thermally dissociate a reactive species, such as atomic or molecular fluorine. For chamber cleaning, the reactive neutral species are transported to the CVD chamber where they chemically react with unwanted deposits on the interior walls.

- **Semiconductor Manufacture:** Any process or operation performed to produce semiconductor devices or related solid state devices. It includes, but is not limited to, the manufacturing of diodes, zeners, stacks, rectifiers, integrated microcircuits, transistors, solar cells, light-sensing devices, and light-emitting devices.

# **Preliminary Survey Results and Emissions Estimates**

# Response Rate

- 304 Surveys Sent in December 2007
- 90% Response Rate
  - 273 Surveys Received

# Size of Industry

- Over 100 Semiconductor and Related Devices Facilities
  - Manufacturers
  - Research and Development Facilities
  - Universities



# Use of Fluorinated Gases (FGs)

- Top 3 FGs Used
  - 36% C<sub>2</sub>F<sub>6</sub>
  - 20% NF<sub>3</sub>
  - 15% CF<sub>4</sub>
- FGs Used By Process

CVD Cleaning	Etching	Other Processes
61%	36%	3%

# Control Technologies

- 41 Facilities Use Control Technologies
  - 19 Facilities Use Abatement for CVD Cleaning and Etching
  - 12 Facilities Use Abatement for Etching Only
  - 10 Facilities Use Abatement for CVD Cleaning Only
- 77% of Usage is From Facilities with FG Control Technologies

# Preliminary Emissions Estimates

## Million Metric Tons of CO<sub>2</sub> Equivalent in 2006 (MMTCO<sub>2</sub>E)

MMTCO <sub>2</sub> E (excludes NF <sub>3</sub> )	MMTCO <sub>2</sub> E (includes NF <sub>3</sub> )
0.38 <sup>1</sup>	0.43 <sup>2</sup>

### Notes:

1. Emissions estimate is based on the IPCC 1996 GWP values, and excludes NF<sub>3</sub>.
2. Emissions estimate is based on the IPCC 1996 GWP values for 6 FGs, and the IPCC 2006 GWP value for NF<sub>3</sub>.

# Future Activities

- Work Group and Individual Meetings: May and June 2008
- Third Workshop: July 2008
- Board Hearing: December 11, 2008
- Regulation Legally Effective: January 1, 2010

# Reminder

- Today's presentation is posted at:  
**<http://www.arb.ca.gov/cc/semiconductors/meetings/meetings.htm>**
- The semiconductor list serve is at:  
**<http://www.arb.ca.gov/listserv/semiconductors.htm>**

# ARB Points of Contact

**Terrel Ferreira, Manager**  
**tferreir@arb.ca.gov**  
**(916) 445-3526**

**Dale Trenchel, Lead**  
**dtrench@arb.ca.gov**  
**(916) 324-0208**

**Lynn Yeung,**  
**Air Pollution Specialist**  
**lyeung@arb.ca.gov**  
**(916) 324-0210**

**Andrew Mrowka,**  
**Air Resources Engineer**  
**amrowka@arb.ca.gov**  
**(916) 324-0330**